Run II Status

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Temple Review

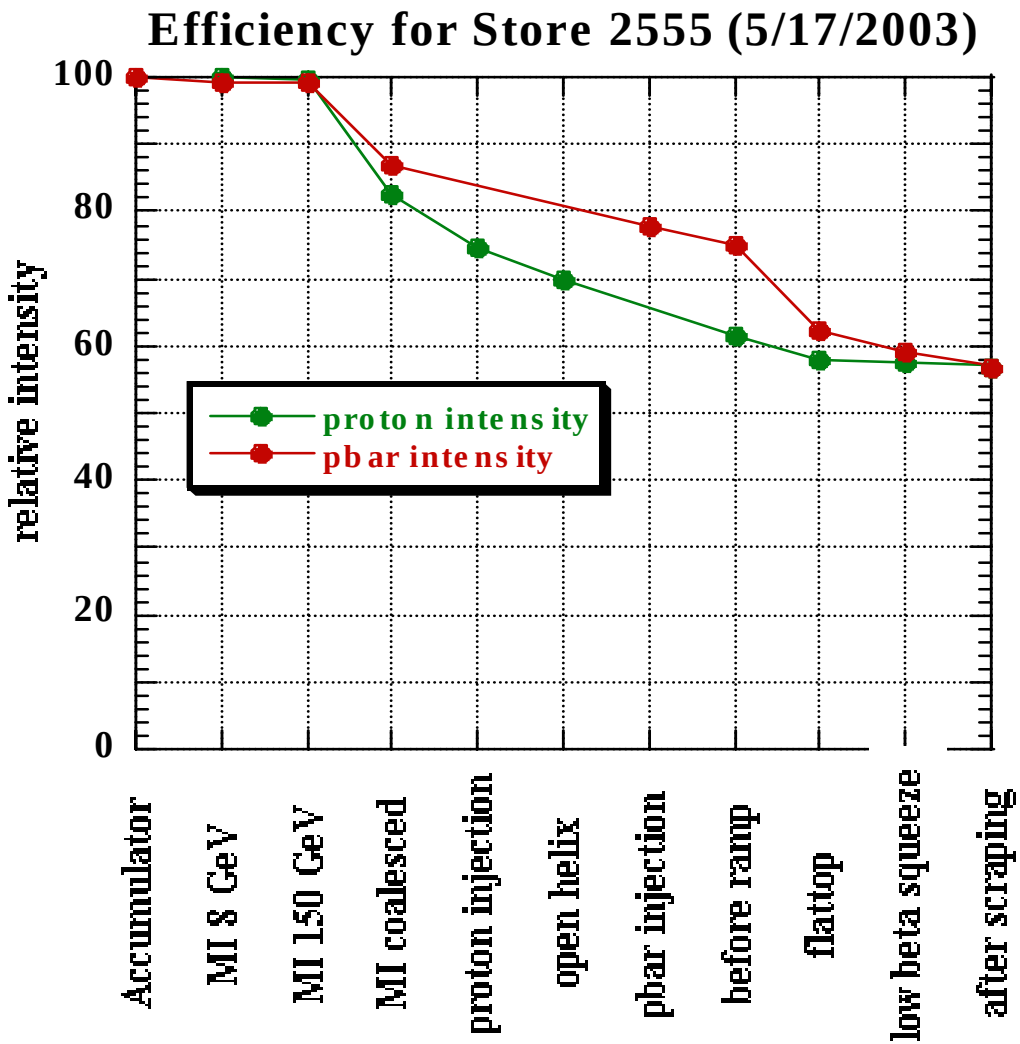
July 1, 2003

Status on Luminosity Parameters

	best luminosity store 1 year ago (1335)	highest luminosity stores to date (2538/2555)	FY03 stretch goals ("routinely")
antiproton stacksize for shot (E10)	131	149/173	155
extraction efficiency from core	.79	.94/.94	.90
pbar xfer efficiency to low beta	.42	.65/.57	.80
pbars/bunch at low beta (E9)	12.1	25.5/25.5	31.0
protons/bunch at low beta (E9)	177	224/242	240
peak luminosity (E31 $cm^{-2}sec^{-1}$)	1.95	4.48/4.48	6.60

Beam Intensity during Shot

- Booster can produce adequate # protons for Tevatron Run II intensity goals
- Accumulator can produce (almost) adequate # antiprotons for FY03 luminosity goals
- Emittance growth produces poor efficiencies



Proton Source Issues

-**Proton Source has increased throughput over the last year (see slides). With the Main Injector, the Proton Source delivers 5e12 proton to the antiproton production target routinely while providing beam to MiniBooNE.**

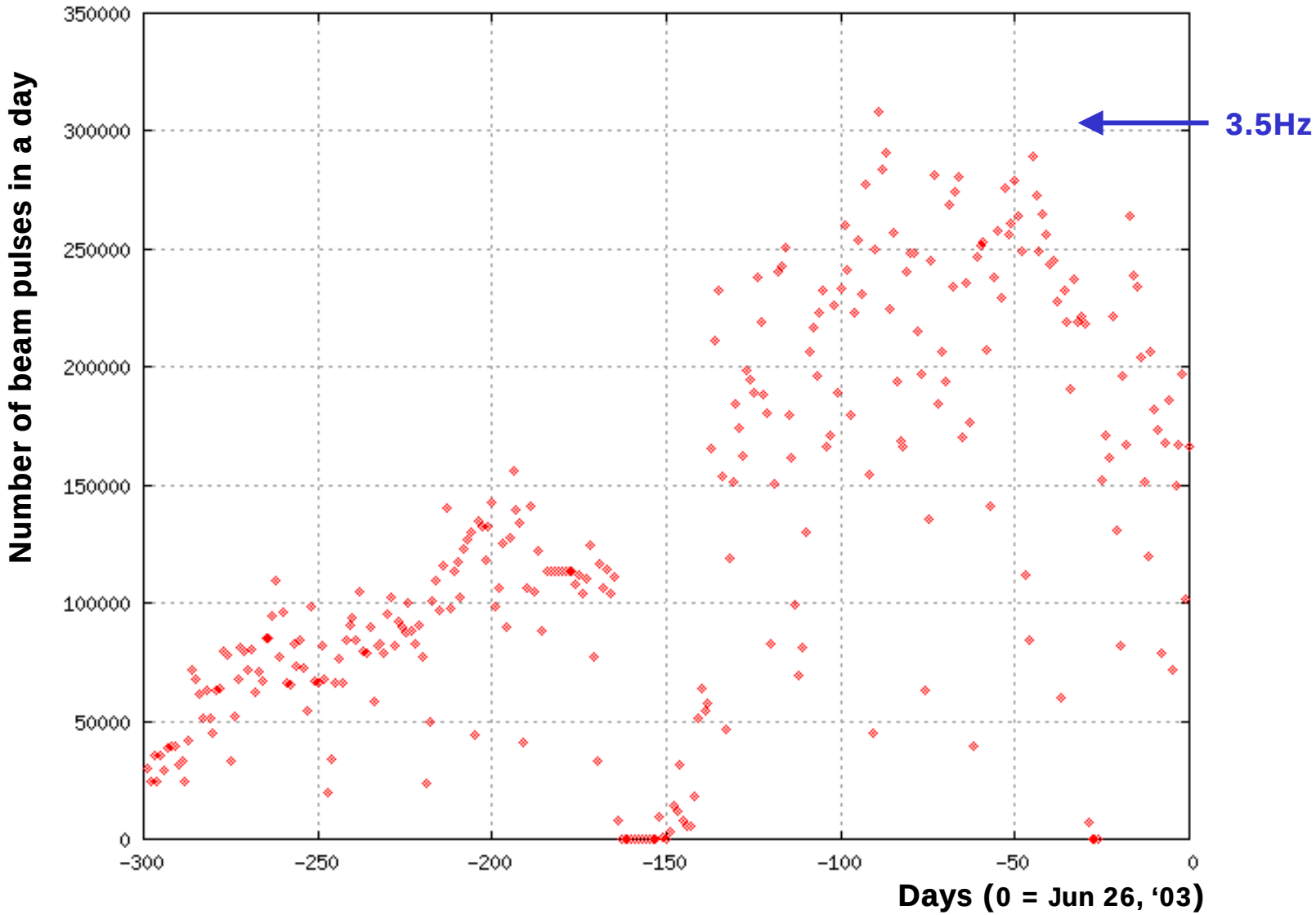
-**Dogleg reduction (improved performance to date mostly due to this). Plans to further reduce one dogleg during shutdown (see slides). This has the greatest potential for Booster improvement.**

-**Collimators to be installed this shutdown. This should remove largest radiation loss from Booster ring proper. Next limits are expected to be injection and extraction areas.**

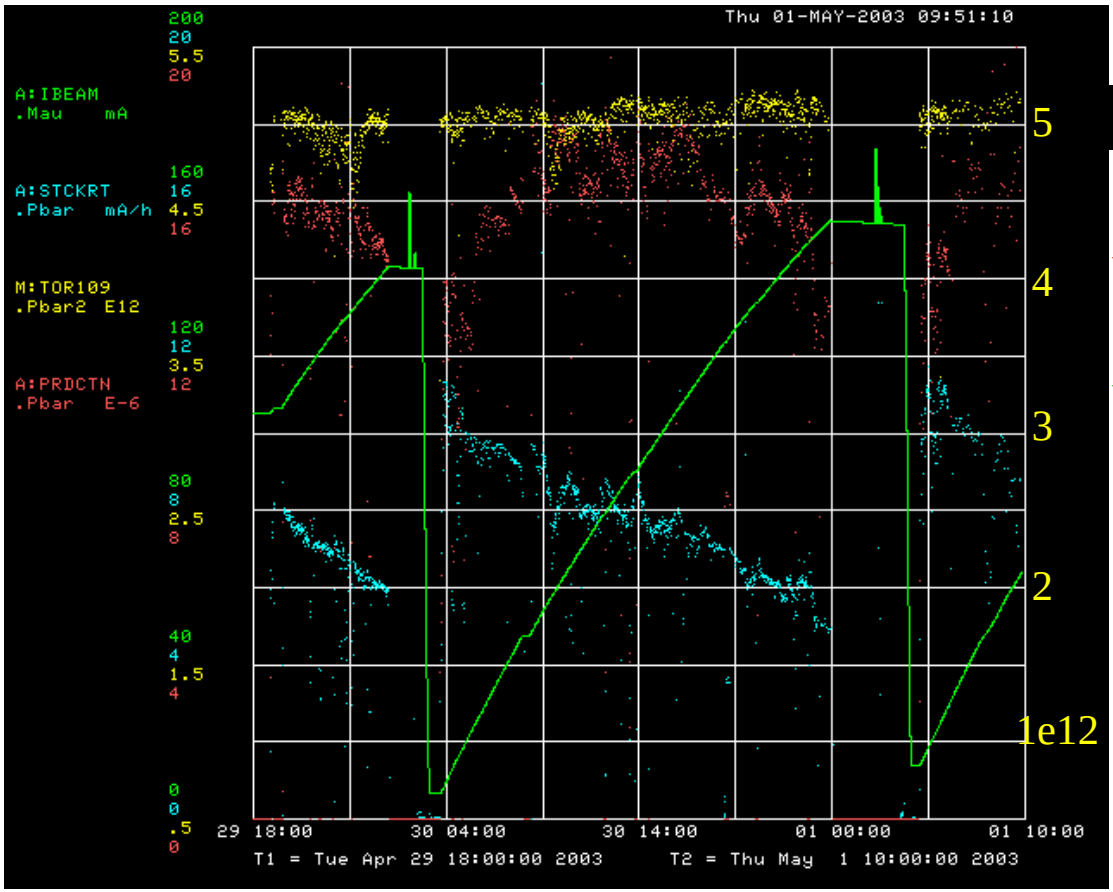
-**400 MeV Lambertson installation during next shutdown. The better designed and larger injection aperture will allow better tuning of Linac and reduce losses.**

-**EDWA magnet installation during next shutdown. Currently at intensity limit before tripping radiation monitors. Larger aperture at extraction will eliminate loss point.**

Proton Source Performance



Proton Source Performance



Plot is over 40hr period

Protons on production target

Antiproton production/proton

Antiproton beam current

Stacking Rate

Recent stacking performance. Also providing >4E16 protons/hour to MiniBooNE

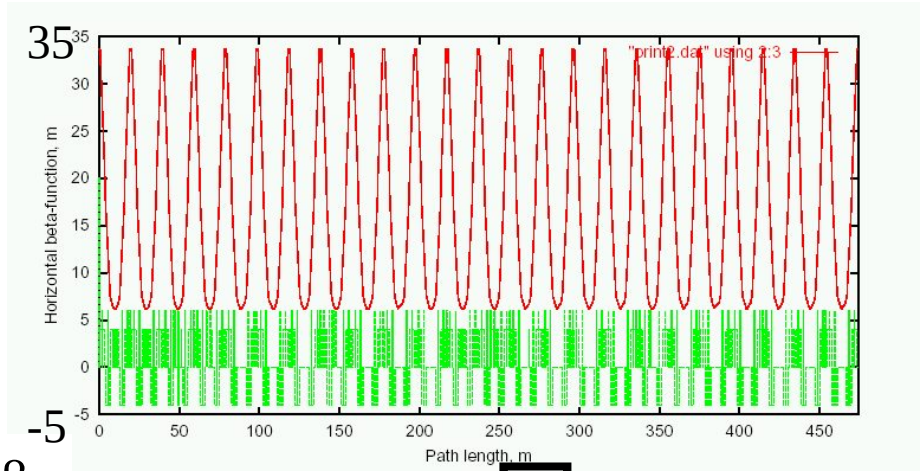
Booster Dogleg

- Each of the two Booster extraction septa has a set of *vertical* dogleg magnets to steer the beam around it during acceleration.
- More powerful doglegs were installed in 1998 to reduce losses early in the cycle.
- These magnets have an edge focusing effect which distorts the *horizontal* injection lattice:
  - 50% increase in maximum β
  - 100% increase in maximum dispersion.
  - Harmonic contributions.
- Effect goes like I^2. Now tune to minimize.
- Recently got an unusual opportunity to explore potential improvements from fixing the problem.
- Working on schemes to reduce or remove problem.

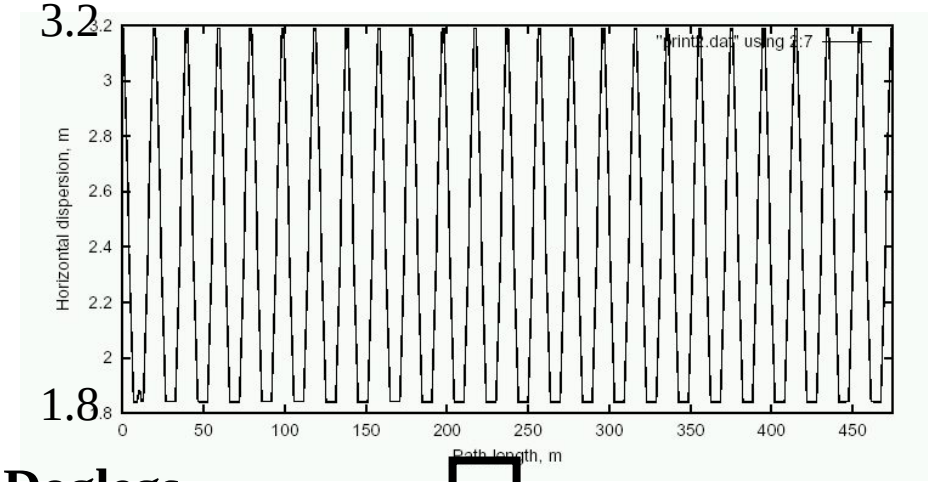
(from E. Prebys)

Booster Dogleg (continued)

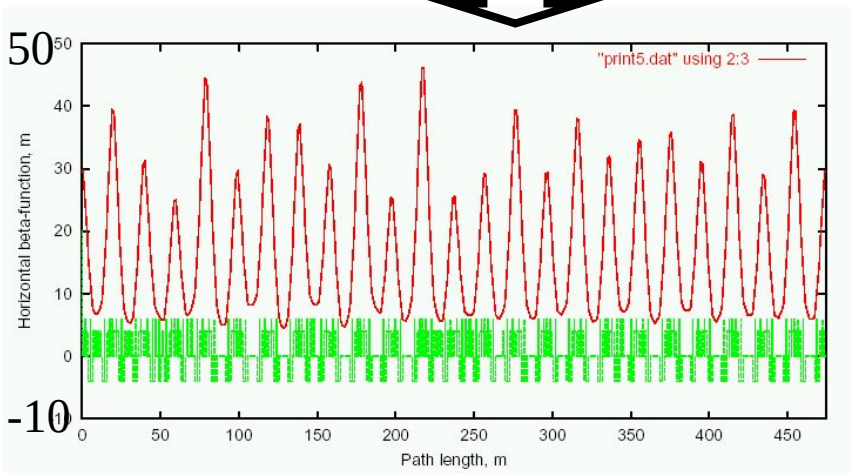
Ideal Lattice



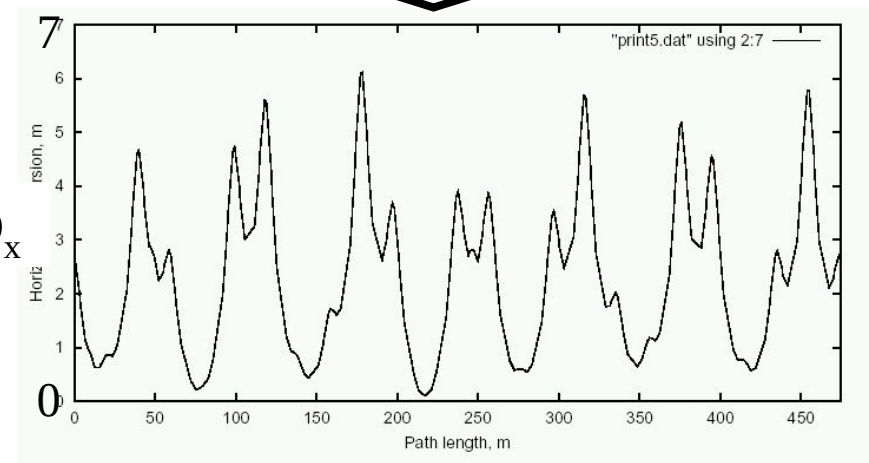
β_x



Add Doglegs



D_x



(from E. Prebys)

Antiproton Source Issues

- **Since the Fall, several small incremental changes have enhanced stacking rate and quality of antiproton beam delivered.**
- **Stack rate falls with stack size (see slide). Stack rate limited by Debuncher momentum cooling (see slide). New equalizers to be installed during shutdown.**
- **Core transverse emittances during shots are adequate to meet Run II goals for stack sizes up to ~250E10 (see slide)**
- **<u>Average</u> longitudinal emittance for shots is 1.1 eV-sec/bunch (measured on AP1 wall current monitor). This should be good enough for 3 eV-sec at low beta. (see slide)**
- **Best stacking rate is 13.5 E10 for 1 hour. Average stacking rate is ~7.5 E10/hr.**

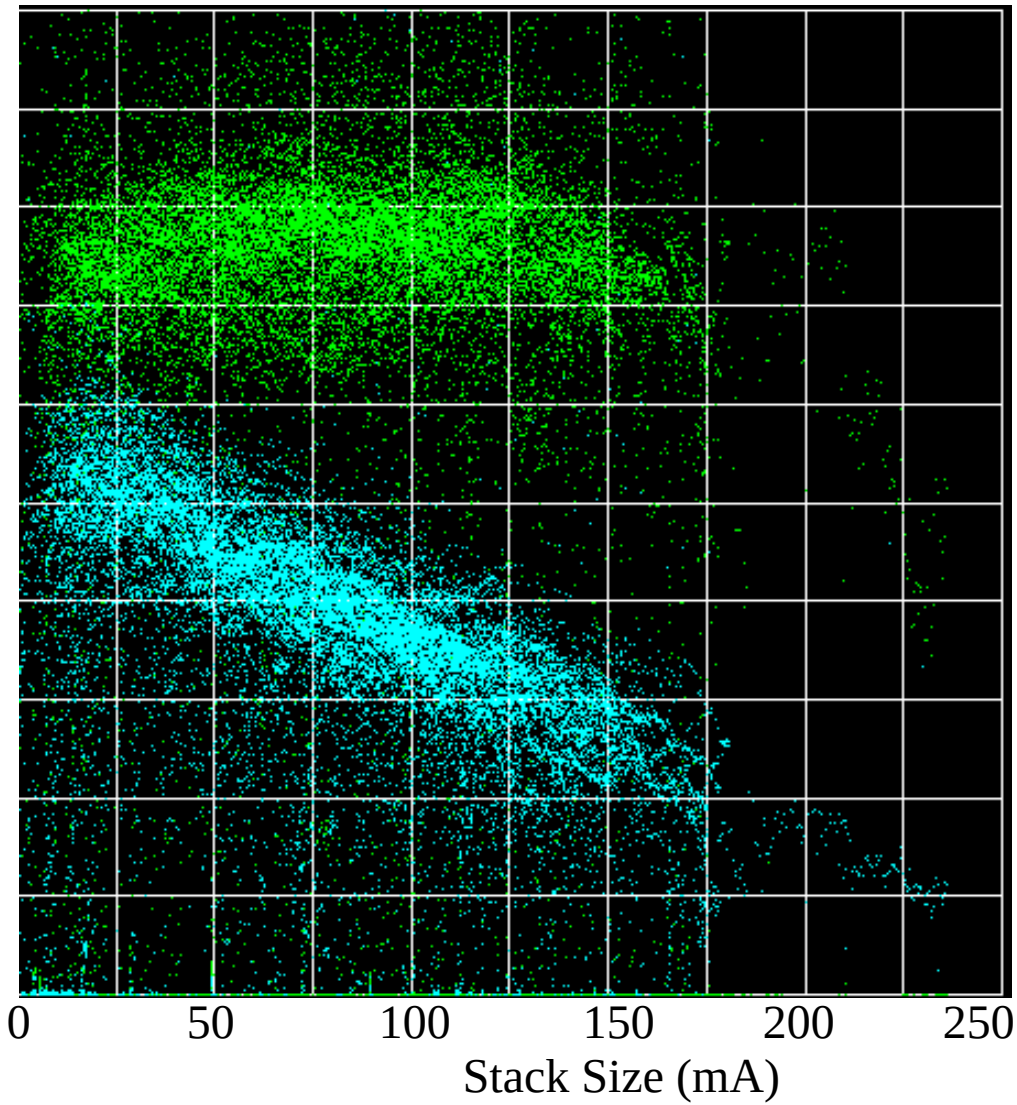
Antiproton Stacking

Antiproton produced per 10e6 on target

Stacking Rate (mA/hr)

Data are from the last 12 weeks

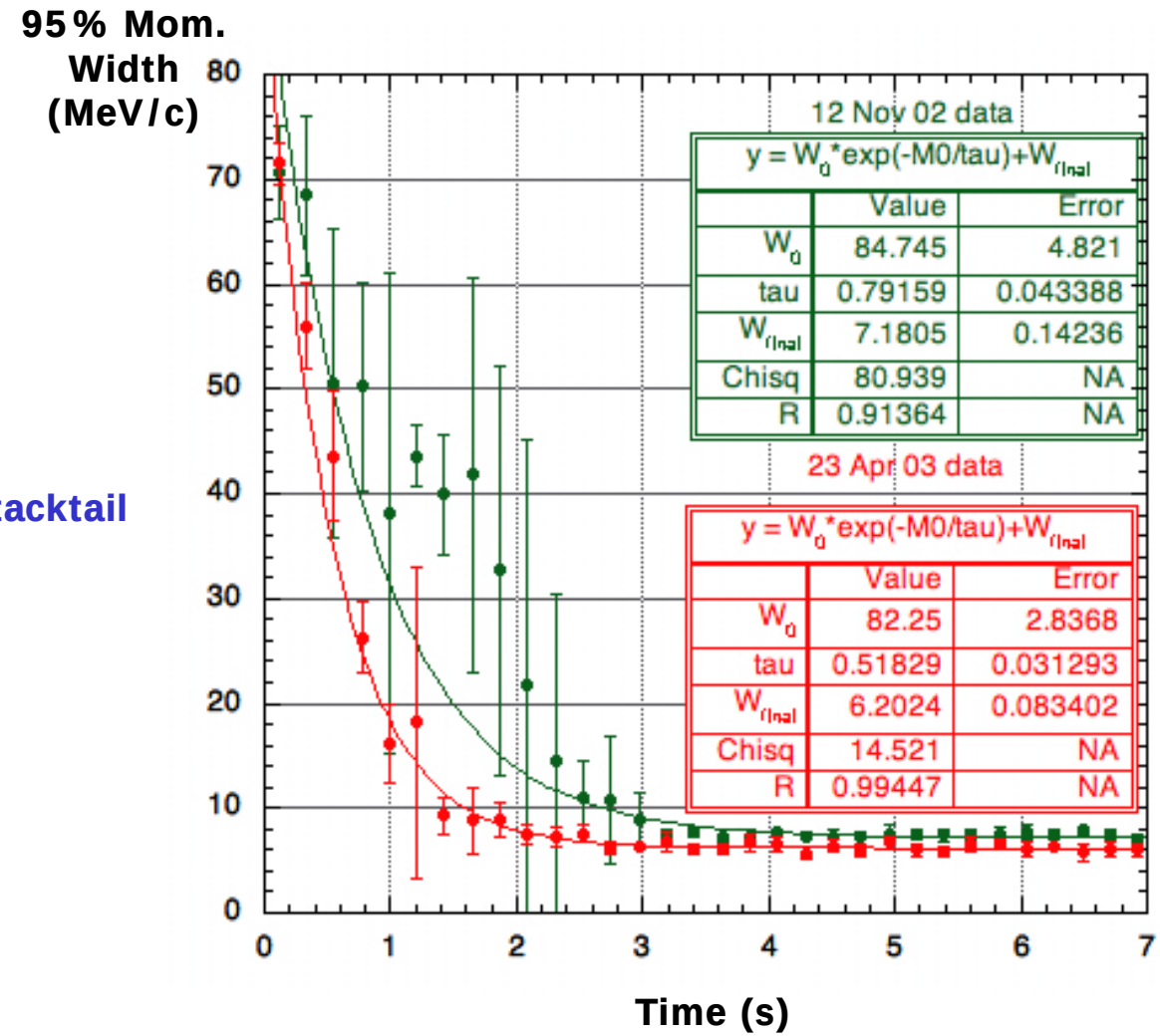
Largest Stack to Date 236mA



Debuncher Momentum Cooling

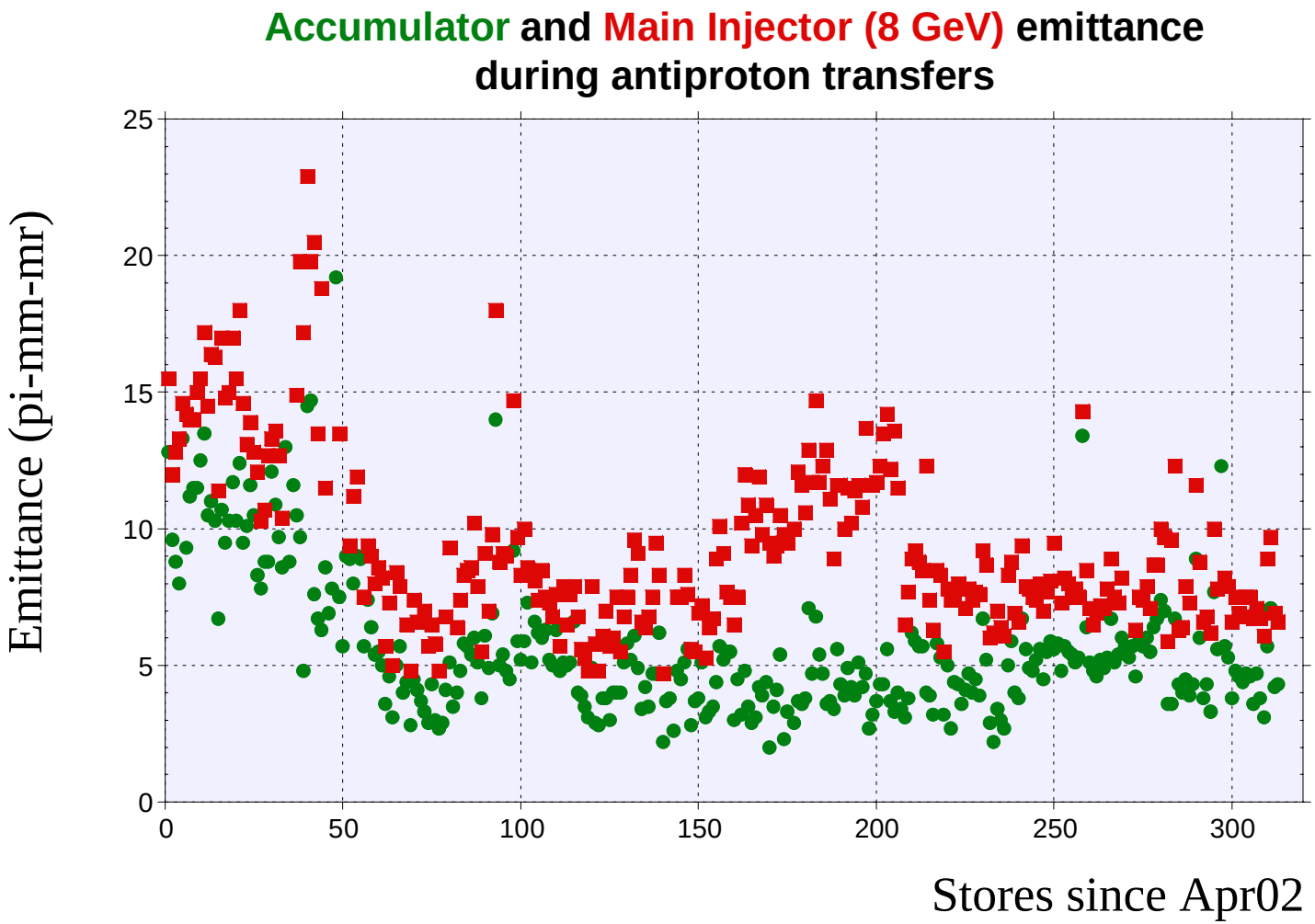
- **Stacking upgrades**

- Major emphasis has been on Debuncher momentum cooling, stacktail cooling system, and yield into Debuncher (AP2 and target).



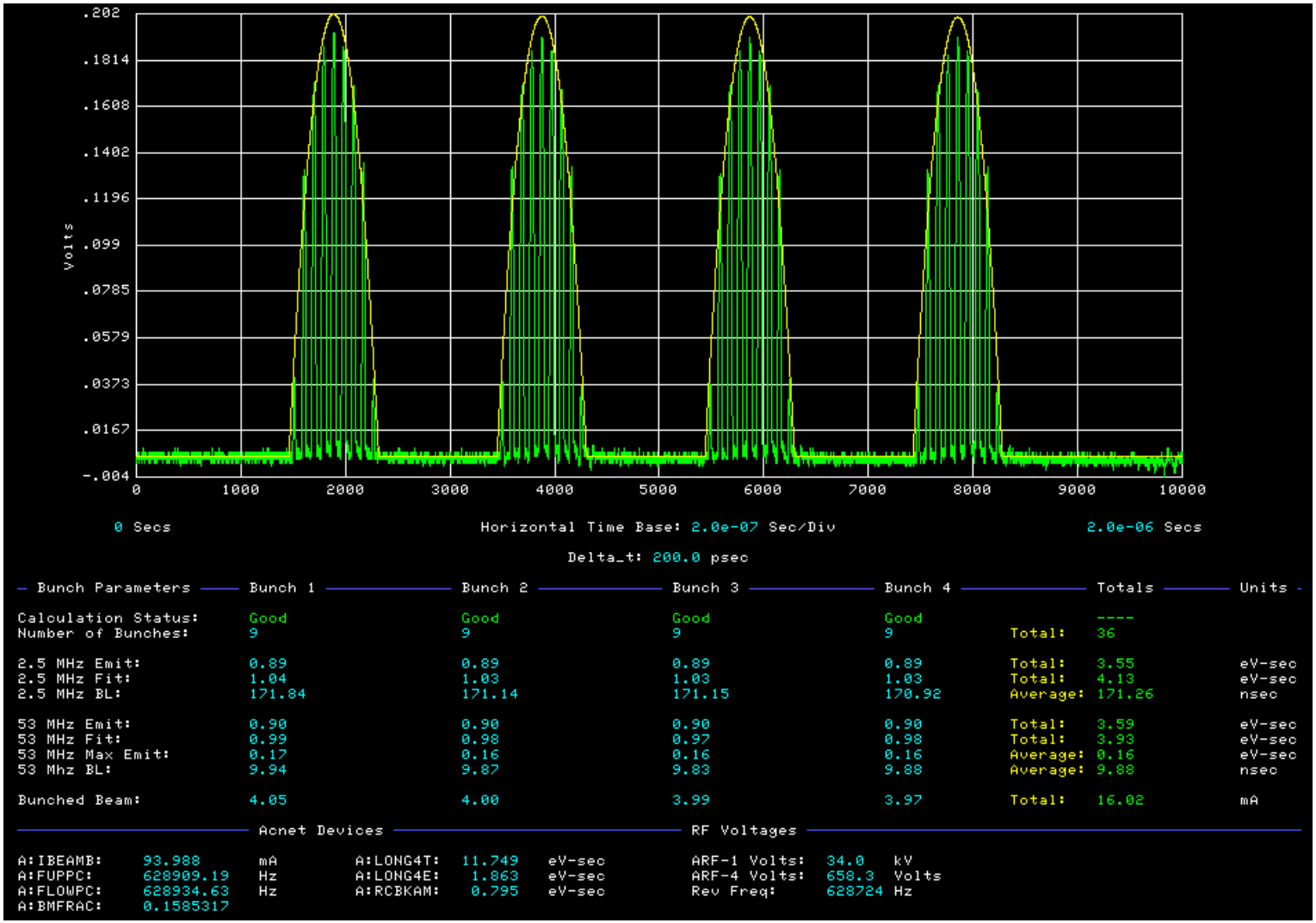
from P. Derwent

Antiproton Transverse Emittance



from J. Morgan

Antiproton Longitudinal Emittance



Bunch Parameters	Bunch 1	Bunch 2	Bunch 3	Bunch 4	Totals		Units
Calculation Status:	Good	Good	Good	Good		----	
Number of Bunches:	9	9	9	9	Total:	36	
2.5 MHz Emit:	0.89	0.89	0.89	0.89	Total:	3.55	eV-sec
2.5 MHz Fit:	1.04	1.03	1.03	1.03	Total:	4.13	eV-sec
2.5 MHz BL:	171.84	171.14	171.15	170.92	Average:	171.26	nsec
53 MHz Emit:	0.90	0.90	0.90	0.90	Total:	3.59	eV-sec
53 MHz Fit:	0.99	0.98	0.97	0.98	Total:	3.93	eV-sec
53 MHz Max Emit:	0.17	0.16	0.16	0.16	Average:	0.16	eV-sec
53 Mhz BL:	9.94	9.87	9.83	9.88	Average:	9.88	nsec
Bunched Beam:	4.05	4.00	3.99	3.97	Total:	16.02	mA

Acnet Devices					RF Voltages		
A:IBEAMB:	93.988	mA	A:LONG4T:	11.749 eV-sec	ARF-1 Volts:	34.0	kV
A:FUPPC:	628909.19	Hz	A:LONG4E:	1.863 eV-sec	ARF-4 Volts:	658.3	Volts
A:FLOWPC:	628934.63	Hz	A:RCBKAM:	0.795 eV-sec	Rev Freq:	628724	Hz
A:BMFRAC:	0.1585317						

AP1 wall current monitor for a pbar transfer

Main Injector Issues

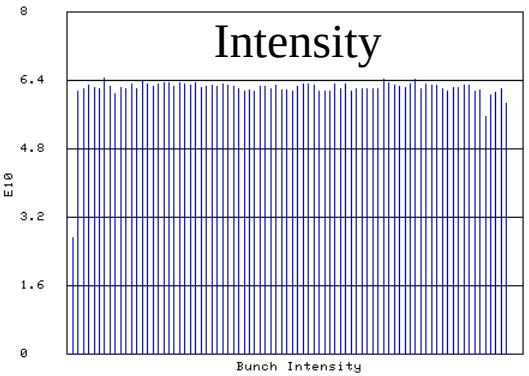
Beam-loading compensation on ramps: Study has shown that BLC during stacking ramp helps beam quality on target. Should provide help with ramping antiprotons.

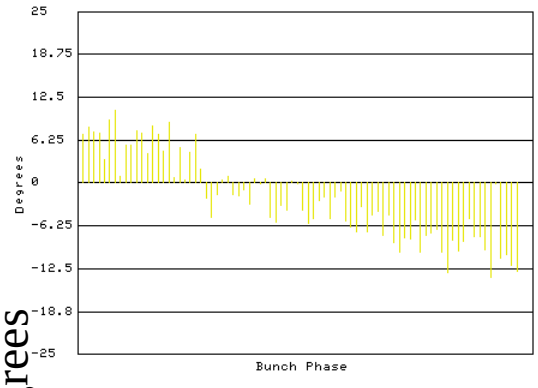
Longitudinal Dampers: Instability is a problem on ramping protons to 150GeV. Cavities are ready for installation, but will take 3 days for installation. One of two amplifiers has been delivered. This should help with all efficiencies (coalescing, transfer to TeV, 150GeV TeV lifetime, and ramp).

Transverse injection dampers should reduce emittance growth ~1 pi for protons, 1-2 pi for pbars. Commissioning has just started.

Other on-going studies: 2.5 MHz acceleration; slip stacking; multi-batching for NUMI; SY120

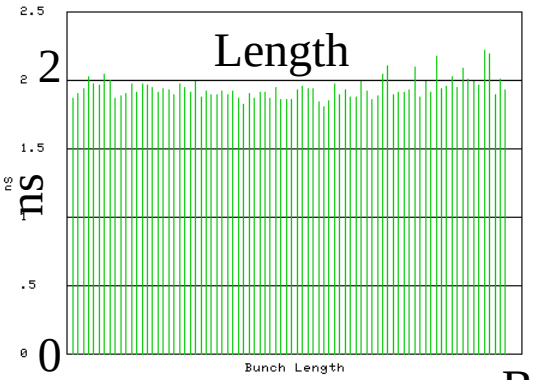
Main Injector Beam Loading Compensation

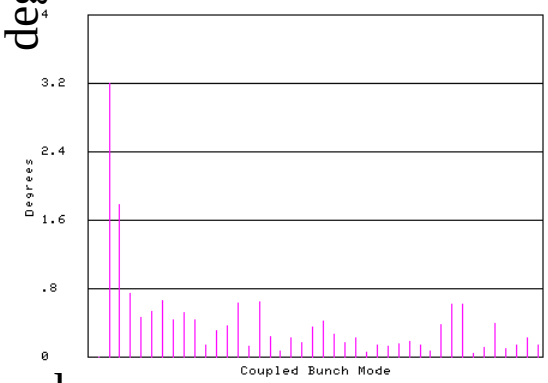


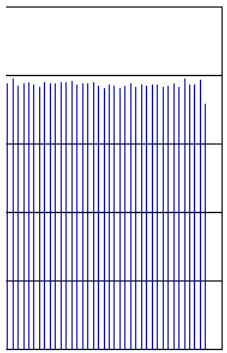


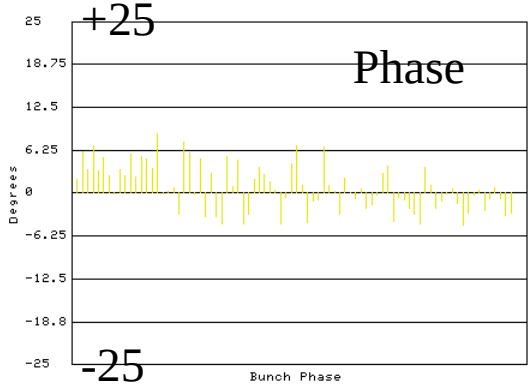
Without BLC

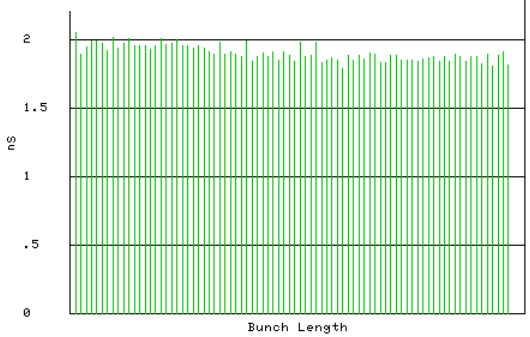
With BLC

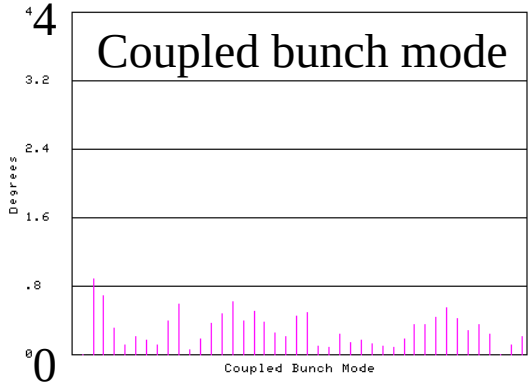












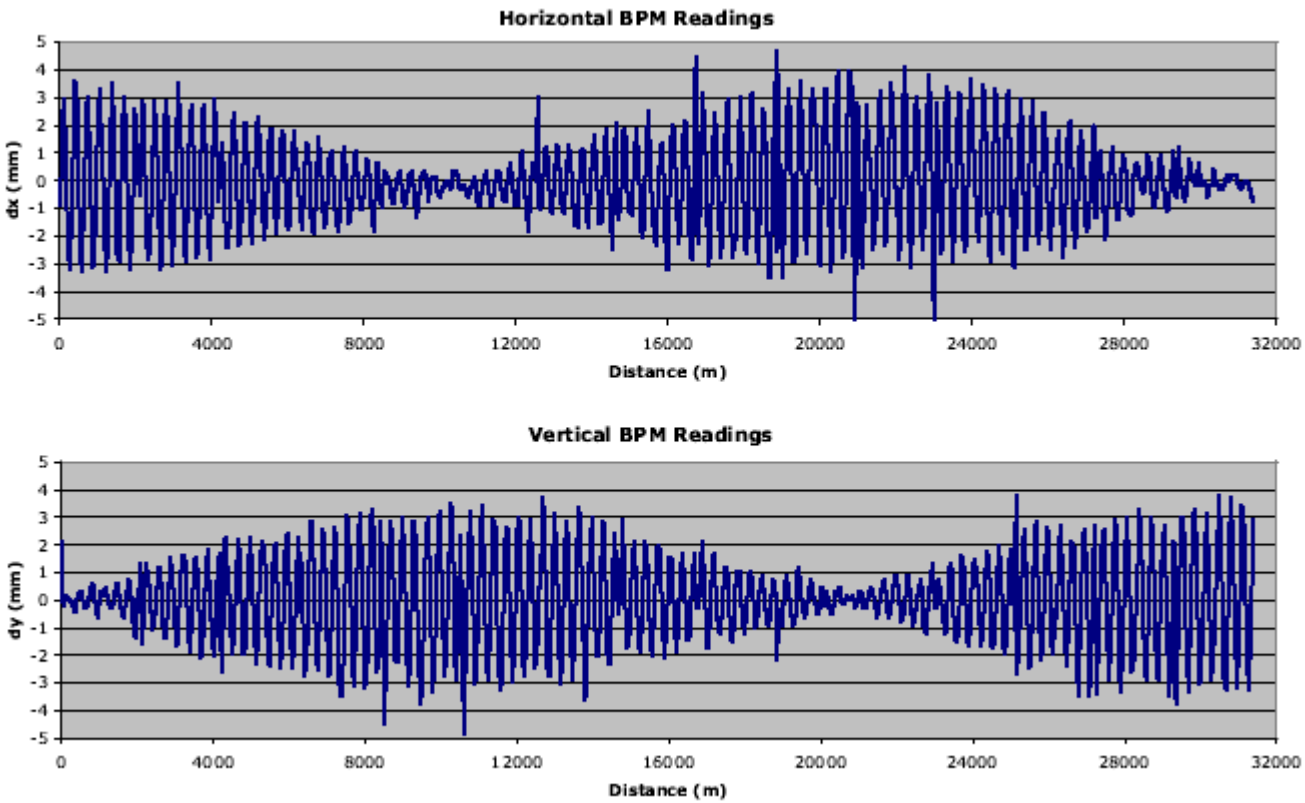
Tevatron Issues

- **P150 transfers cause emittance blowup of >4π mm-mr.**
- **A150 transfers cause emittance blowup of >6π mm-mr.**
- **Transverse dampers @ 150 GeV allow lower chromaticity, better lifetime; not yet commissioned on ramp – excessive local coupling makes commissioning on ramp difficult.**
- **Coupling -- major source identified; will start correcting this shutdown (see slides); impact on Tevatron performance not known.**
- **C0 Lambertson removed in January. The immediate impact was a change in machine impedance which allowed more protons. Study time is required to commission new helix (already modified orbit to improve aperture); main hope is to improve lifetime @ 150 GeV and reduce losses at beginning of ramp.**
- **Now the major transverse impedance is from F0 Lamb laminations (see slide). Will install liner during shutdown.**
- **Octupoles for stabilization – some studies done; no estimate for completion; limited studies so far indicate this can help lifetime @ 150 GeV**
- **Injection dampers should improve proton emittance by ~1π mm-mr; pbar emittance by ~2π mm-mr; waiting for power amplifiers to arrive.**
- **Alignment – There is a tentative shutdown proposal; will be reviewed early July.**

Tevatron coupling

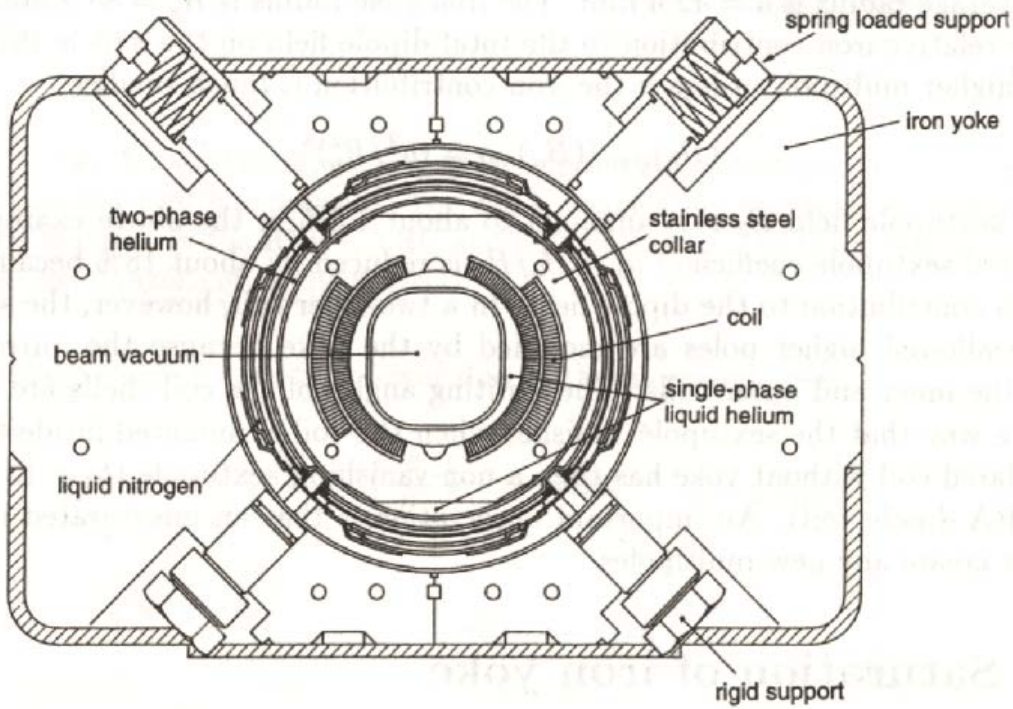
Data shows in-plane and out-of-plane difference orbits after single horizontal kick. Data is for 1st 5 turns in Tevatron.

from M. Syphers



Coupling in Tevatron is ~uniform around the ring and is consistent with ~1.5 units of a_1 per dipole. This is compensated by a distributed skew quad circuit of 42 elements.

Tevatron coupling (continued)



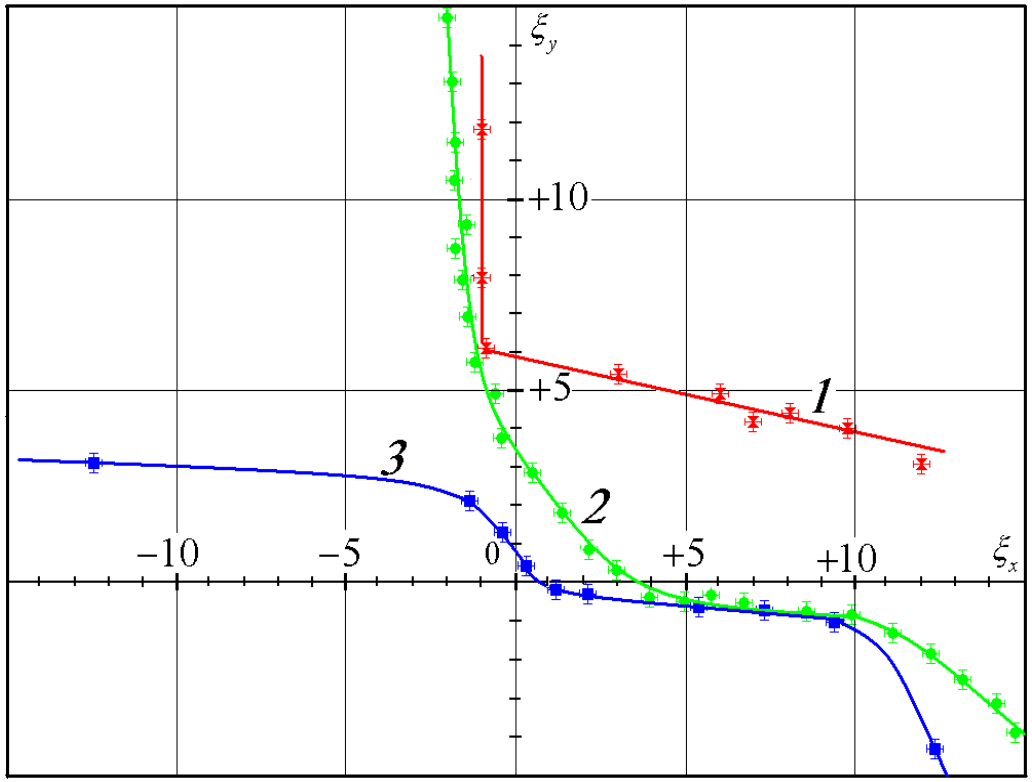
Tevatron dipole cross section

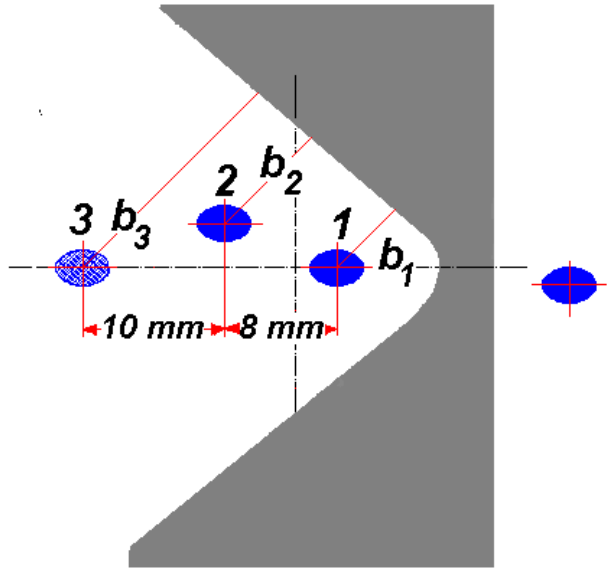
Tevatron coil and cryostat assembly is held within the iron by 4 supports at 9 locations along the length of the magnet. Recent measurements of the "smart bolts" (upper supports) on 18 magnets in the tunnel, indicate that the coil assembly has sagged by ~2 mils from original. This is enough to produce ~1 unit of a1 per dipole.

In 1984, compensating skew quad circuit was running at ~2A. From 1995 compensating skew quad circuit has been running at ~24A (@ 800 GeV).

from P. Bauer

Tevatron F0 Lambertson





1 is Injection Orbit

2 is Central Orbit

3 is Local Orbit Bump

For each orbit, the instability thresholds as functions of H & V chromaticities

Will install thin inner liner with high electrical conductivity and high thermal conductivity {Cu-Be bronze C17200: Be 1.9%, Co 0.2%, Cu 97.9 %}

from P. Ivanov

Recycler Commissioning

- Prior to January shutdown beam lifetime was >100 hours, with equilibrium emittance of ~7 π-mm-mrad and ~75 eV-sec with 70E10 antiprotons.

- During the shutdown the number of ion pumps was doubled in ~3/4 of the ring, ~20% of the ring was baked, and additional instrumentation was added.

-Since the shutdown the beam lifetime has been ~3 times worse, and the emittance growth rate ~3 times faster. Contaminated vacuum is thought to be the culprit.

-Some instrumentation and beam pipe will be removed and those sections will be re-baked in order to recover (at least) the previous vacuum.

-Stochastic cooling systems have been commissioned; transverse emittance monitor has been commissioned; beam line tuner has been commissioned

-New BPM system is being built and commissioned; it is scheduled for completion of installation by Summer shutdown.

-Ramped correctors have been commissioned – horizontal orbit distortions due to MI ramps have been reduced to <.3mm rms.

Agenda for FY03

- **Maximize luminosity between now and August 25**
  - **Dedicated studies limited due to the need to reach 225 pb^{-1} for FY03; studies are almost entirely "maintenance"**

- **7 week shutdown starting August 25**
  - **Recycler vacuum; e-cooling civil construction; Tevatron F0 Lambertson modification; Tevatron collimator @A4; Tevatron alignment; additional shielding for CDF detector; Debuncher movable quad installation; AP2 aperture increase; Booster dogleg modification; NUMI installation work; infrastructure maintenance (full scope of work not yet determined)….**

Summary

- **Factor of 2.3 increase in peak luminosity over last 12 months**
- **Factor of 2.3 increase in weekly integrated luminosity over last 12 months**
- **Progress on instrumentation**
- **Improvements in theoretical understanding of issues**
- **Summer shutdown projects should lead to additional luminosity increases**